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PATENT

UNITED STATES PATENT APPLICATION

of

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for

MULTI-PURPOSE INJECTION AND PRODUCTION WELL SYSTEM

TITLE OF THE INVENTION

Multi-Purpose Injection and Production Well System

CROSS REFERENCE TO RELATED APPLICATIONS

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

BACKGROUND OF THE INVENTION

Field of the Invention - This invention is in the field of equipment used in the production of fluids from, and injection of fluids into, oil and gas wells having multiple zones.

Background Art - Many oil or gas wells extend through multiple formations, resulting in the establishment of multiple zones at different depths in the well. It may be desirable to produce formation fluids such as gas or oil from different zones at different times, and to inject fluids such as water into different zones at different times, for the purpose of ultimately obtaining the maximum production from the well. Further, it may be desirable to produce formation fluids from one or more zones, while simultaneously injecting fluids into one or more other zones. Finally, it may be desirable to convert a particular zone from a production zone into an injection zone, after the zone is depleted.

Known equipment for these purposes usually requires pulling the completion assembly from the well, and changing or reconfiguring the equipment in the assembly, when it is desired to commence or cease production or injection in a particular zone. Further, known equipment is generally limited to the production of fluid or the injection of fluid at any given time, with simultaneous production and injection not being possible, or at least difficult. More specifically, known equipment is not capable of the simultaneous production from multiple zones and injection into multiple zones.

BRIEF SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for selectively injecting into a given zone or multiple zones, or producing from a given zone or multiple zones, without pulling the equipment from the well. A completion unit is positioned next to each zone of the formation, with zones being segregated by packers. An injection sleeve and a production sleeve are provided in each completion unit. Each sleeve essentially bridges between the completion string and the production string, which is within the completion string. Each sleeve is shifted, such as by hydraulic, electrical, or mechanical operation, to selectively align a conduit through the sleeve with its associated port in the wall of the completion string. When aligned with the inlet port, the conduit in the production sleeve conducts formation fluid into a production fluid path in the production string. When aligned with the outlet port, the conduit in the injection sleeve conducts injection fluid from an injection fluid path into the formation. Regardless of sleeve position, both injection flow and production flow can be maintained through the completion unit to other completion units above or below.

By selectively shifting the sleeves, selected zones can be isolated, produced from, or injected into, as desired. One or more lower zones can be injected into while one or more upper zones are produced from, or vice versa. If desired, alternating zones can even be simultaneously produced from and injected into.

The novel features of this invention, as well as the invention itself, will be best understood from the attached drawings, taken along with the following description, in which similar reference characters refer to similar parts, and in which:

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Figure 1 is a longitudinal section of a production unit as implemented in the present invention, with production flow from the zone isolated;

Figure 2 is a transverse section of a production sleeve as used in the production unit of Figure 1;

Figure 3 is a longitudinal section of the production unit of Figure 1, with production flow from the zone established;

Figure 4 is a longitudinal section of an injection unit as implemented in the present invention, with injection flow into the zone isolated;

Figure 5 is a transverse section of an injection sleeve as used in the injection unit of Figure 4;

Figure 6 is a longitudinal section of the injection unit of Figure 4, with injection flow into the zone established;

Figure 7 is a longitudinal section of a completion unit, showing production flow from the zone established, and showing an alternative configuration of the completion and production strings;

Figure 8 is a longitudinal section of the completion unit of Figure 7, showing production flow from the zone and injection flow into the zone both isolated; and

Figure 9 is a longitudinal section of the completion unit of Figure 7, showing injection flow into the zone established.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Figure 1, a production unit 10 used as part of the present invention includes a completion string 12 of tubing or piping, a production string 14 of tubing or piping, one or more centralizing rings 16, and a longitudinally shiftable production sleeve 18. This production unit can be placed in a well bore, aligned with a selected zone of the downhole formation. The completion string 12 shown is flush joint piping, and the production string 14 can be flush joint piping. Other types of piping or tubing can also be used. The production string 14 is substantially coaxially located within the completion string 12, centralized therein by the centralizing rings 16. An upper end 19 and a lower end 21 of the production sleeve 18 are configured to slidably mount within production string fittings 23, for shifting of the production sleeve 18 by means of longitudinal movement relative to the completion string 12. It will be seen that shifting of the production sleeve 18 could be rotational relative to the completion string 12, rather than longitudinal, if desired.

Figure 2 shows a transverse section of the production sleeve 18. One or more production fluid conduits 22 are arranged more or less radially from the center of the production sleeve 18 to its outer periphery. One or more injection fluid bypass channels 24 pass longitudinally through the production sleeve 18, to ensure that

injection fluid can bypass the production sleeve from an upper annulus to a lower annulus. A production fluid flow path 28 passes longitudinally through the production sleeve 18, ensuring the production fluid from a lower zone can pass to an upper zone. The production fluid conduits 22 are also in fluid flow communication with the production fluid flow path 28.

Figure 1 shows only one of the production fluid conduits 22, and only one of the bypass channels 24. However, it can be seen that, regardless of the position of the production sleeve 18, an injection fluid flow path exists through the production sleeve 18 as indicated by the arrow labeled IF. Further, the injection fluid flow path continues through bypass channels 26 in the centralizing rings 16. This allows injection fluid pumped downhole in the annulus between the completion string 12 and the production string 14 to flow completely through the production unit 10 from an upper zone to a lower zone, regardless of the position of the production sleeve 18.

It also can be seen that, regardless of the position of the production sleeve 18, production fluid can flow through the production fluid flow path 28 in the production sleeve 18 as indicated by the arrow labeled PF. Further, production fluid can flow through the center of the centralizing rings 16, in the production fluid flow path 28 in the production string 14. This allows production fluid to flow completely through the production unit 10 from a lower zone to an upper zone, regardless of the position of the production sleeve 18.

Shifting of the production sleeve 18 could be accomplished by several different means, such as hydraulically, mechanically, or electrically, or a combination thereof. Figure 1 shows one embodiment of a hydraulic shifting means, including an upper hydraulic duct 30, a lower hydraulic duct 32, and a two directional hydraulic chamber 34. A shoulder on the production sleeve 18 can be positioned in the hydraulic chamber 34. When the upper duct 30 is pressurized, the production sleeve 18 is shifted downwardly, or to the right in the figure. When the lower duct 32 is pressurized, the production sleeve 18 is shifted upwardly, or to the left in the figure. A similar hydraulic assembly could be used to rotationally shift the production sleeve 18, if preferred. Further, an electrical solenoid mechanism could accomplish either longitudinal or rotational shifting, if preferred. Still further, other known shifting mechanisms could be used to shift the production sleeve 18.

A formation fluid inlet port 20 is formed through the wall of the completion string 12. The production fluid conduit 22 in the production sleeve 18 does not align with the inlet port 20, when the production sleeve 18 is in the upper position shown in Figure 1. This isolates the inlet port 20, preventing flow of formation fluid through the inlet port 20, through the production fluid conduit 22, and into the production fluid flow path 28. Figure 3 illustrates that the production sleeve 18 can be selectively shifted downwardly when desired, to align the production fluid conduit 22 with the inlet port 20. This establishes flow of formation fluid through the inlet port 20, through the production fluid conduit 22, and into the production fluid flow path 28.

As shown in Figure 4, an injection unit 40 used as part of the present invention includes the completion string 12, the production string 14, one or more centralizing rings 16, and a longitudinally shiftable injection sleeve 42. This injection unit also can be placed in a well bore, aligned with a selected zone of the downhole formation. As will be seen, the injection unit 40 can be associated with a production unit 10 for a particular zone of the formation, to facilitate selective production from, or injection into, the zone. An upper end 43 and a lower end 45 of the injection sleeve 42 are configured to slidably mount within production string fittings 23, for shifting of the injection sleeve 42 by means of longitudinal movement relative to the completion string 12. It will be seen that shifting of the injection sleeve 42 could be rotational relative to the completion string 12, rather than longitudinal, if desired.

Figure 5 shows a transverse section of the injection sleeve 42. One or more injection fluid conduits 46 are arranged at several locations, connecting the upper side of the injection sleeve 42 to its outer periphery. One or more injection fluid bypass channels 56 pass longitudinally through the injection sleeve 42, to ensure that injection fluid can bypass the injection sleeve from an upper annulus to a lower annulus. A production fluid flow path 28 passes longitudinally through the injection sleeve 42, ensuring the production fluid from a lower zone can pass to an upper zone.

Figure 4 shows only one of the injection fluid conduits 46, and only one of the bypass channels 56. However, it can be seen that, regardless of the position of the injection sleeve 42, an injection fluid flow path exists through the injection sleeve 42 as indicated by the arrow labeled IF. Further, the injection fluid flow path continues through bypass channels 26 in the centralizing rings 16. This allows injection fluid

pumped downhole in the annulus between the completion string 12 and the production string 14 to flow completely through the injection unit 40 from an upper zone to a lower zone, regardless of the position of the injection sleeve 42.

It also can be seen that, regardless of the position of the injection sleeve 42, production fluid can flow through the production fluid flow path 28 in the injection sleeve 42 as indicated by the arrow labeled PF. Further, production fluid can flow through the center of the centralizing rings 16, in the production fluid flow path 28 in the production string 14. This allows production fluid to flow completely through the injection unit 40 from a lower zone to an upper zone, regardless of the position of the injection sleeve 42.

Shifting of the injection sleeve 42 could be accomplished by several different means, such as hydraulically, mechanically, or electrically, or a combination thereof. Figure 4 shows one embodiment of a hydraulic shifting means, including an upper hydraulic duct 50, a lower hydraulic duct 52, and a two directional hydraulic chamber 54. A shoulder on the injection sleeve 42 can be positioned in the hydraulic chamber 54. When the upper duct 50 is pressurized, the injection sleeve 42 is shifted downwardly, or to the right in the figure. When the lower duct 52 is pressurized, the injection sleeve 42 is shifted upwardly, or to the left in the figure. A similar hydraulic assembly could be used to rotationally shift the injection sleeve 42, if preferred. Further, an electrical solenoid mechanism could accomplish either longitudinal or rotational shifting, if preferred. Still further, other known shifting mechanisms could be used to shift the injection sleeve 42.

An injection fluid outlet port 44 is formed through the wall of the completion string 12. The injection fluid conduit 46 in the injection sleeve 42 does not align with the outlet port 44, when the injection sleeve 42 is in the upper position shown in Figure 4. This isolates the outlet port 44, preventing flow of injection fluid through the injection fluid conduit 46, through the outlet port 44, and into the formation. Figure 6 illustrates that the injection sleeve 42 can be selectively shifted downwardly when desired, to align the injection fluid conduit 46 with the outlet port 44. This establishes flow of injection fluid through the injection fluid conduit 46, through the outlet port 44, and into the formation.

Figures 7, 8, and 9 illustrate the pairing of a production unit 10 with an injection unit 40 to form a completion unit, which can be placed downhole in a well bore, aligned with a selected zone of the formation. Packers 58 can be used to isolate adjacent zones. Figures 7, 8, and 9 also illustrate a variation of the configuration of the completion string and the production string, when it is desired to pump injection fluid into the annulus surrounding the completion string, rather than pumping injection fluid into an annulus between the completion string and the production string, as in the embodiments shown in Figures 1, 3, 4, and 6. In either embodiment, however, production fluid flow and injection fluid flow can be controlled as shown in Figures 7, 8, and 9.

Figure 7 shows the production sleeve 18 in its lower position, and the injection sleeve 42 in its upper position. This establishes flow of formation fluid from the zone into the production fluid flow path 28, while preventing flow of injection fluid into the zone. Figure 8 shows the production sleeve 18 in its upper position, and the injection sleeve 42 in its upper position. This prevents flow of formation fluid from the zone into the production fluid flow path 28, while also preventing flow of injection fluid into the zone. Figure 9 shows the production sleeve 18 in its upper position, and the injection sleeve 42 in its lower position. This prevents flow of formation fluid from the zone into the production fluid flow path 28, while establishing flow of injection fluid into the zone.

It can be seen that, by selective shifting of the production sleeves 18 and the injection sleeves 42 in multiple zones, one or more zones can produce formation fluid, simultaneous with the injection of fluid into one or more other zones.

While the particular invention as herein shown and disclosed in detail is fully capable of obtaining the objects and providing the advantages hereinbefore stated, it is to be understood that this disclosure is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended other than as described in the appended claims.